Health, Environment and Regulatory aspects of Water Recycling

International Study Tour

Report

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Mr Hamish McNulty, Executive Director Environment and Recreation
Mr Robert Neil, Director Environment Protection and Heritage

13th – 26th May 2007

Trip Report 13-26 May 2007

1. Executive Summary

This report outlines the visit made by ACT Health and Territory and Municipal Services (TAMS) Senior Staff in response to ACTEW's water2WATER proposal. The delegation represents the ACT's regulatory bodies that will develop the Health and Environmental framework should the water2WATER proposal proceed.

Between 13 May and 26 May 2007 this delegation visited Singapore, Belgium, the United Kingdom and the United States to meet with regulators and treatment plant operators within these countries to discuss drinking water recycling to ensure that the ACT Government received the most up to date information relevant to the project's risks and necessary regulatory controls for both environmental and health related matters.

Attendees

ACT Health:
- Dr Paul Dugdale: Chief Health Officer
- Mr John Woollard: Director - Health Protection Service

TAMS:
- Mr Hamish McNulty: Executive Director Environment and Recreation
- Mr Robert Neil: Director Environment Protection and Heritage

As a result of discussions with various international regulators and treatment plant operators the group formed the following conclusions with respect to drinking water recycling and its application within the ACT:

Conclusion 1: Water reclamation and recycling is achievable in the ACT;
Conclusion 2: There is a body of international opinion/information that supports the ACTEW proposed reverse osmosis membrane based process train option over single or no membrane options;
Conclusion 3: That on the basis of available information ACTEW's reverse osmosis membrane based option would provide the best outcome for the ACT in terms of public health and a range of environmental values. This option does however present significant environmental challenges and these will need to be carefully considered;
Conclusion 4: Water resource availability is the major driver for the water2WATER recycling project and if there is a deterioration in resource availability further pressure will be experienced to fast track the proposal. There may be opportunities to address some of the expected environmental concerns in a staged approach relying on a mix of current and new methods of waste treatment;
Conclusion 5: ACT Health and TAMS should look for ways to participate in the research, regulation and development of drinking water recycling nationally and internationally; and
Conclusion 6: A robust regulatory framework to control drinking water recycling is required in the ACT.

In conjunction with these conclusions, a series of actions have been developed.

Action 1: Request ACTEW to provide performance data, including relevant research findings to compare drinking water recycling options. This data to focus in particular on the efficacy of the options to remove endocrine disruptors, small molecular weights compounds such as NDMA and other byproducts of disinfection, reliability and consistency, capacity for rapid in-process monitoring to detect system problems and future capacity to adapt to emerging chemical contaminants of concern.
Action 2: Request ACTEW to provide advice about increased TDS and nutrient loadings in the Cotter reservoir for its proposed options.
Action 3: Consider direct potable reuse in Health and Environmental Risk Assessments.
Action 4: Request ACTEW to consider strategies to reduce influent loadings to the Lower Molonglo Water Quality Control Centre (LMWQCC) for contaminants such as salt, and pharmaceuticals;
Action 5: ACT Health to collaborate with Singapore SUI to undertake base line analysis of outflows from LMWQCC;
Action 6: ACT Health to source relevant documents associated with the proposed San Diego drinking water recycling project; and
Action 7: ACT Health and EPA to develop regulatory controls for drinking water recycling that are, as far as possible complimentary.

2. Singapore:

• *NEWater Visitor Centre, Bedok .*

On the 14 May the group met with Mr Bernard Koh, General Manager, Singapore Utilities International (SUI); Mr Harry Seah, Director Technology & Water Quality Office, Singapore Public Utilities Board (PUB); Mr Chua Seng Chye, General Manager NEWater factories, PUB; and Ms Josephine Leong Yin Hou, Senior Chemist, PUB at the NEWater Visitor Centre.

NEWater visitor center, Bedok, Singapore.

Bedok NEWater Factory was commissioned in 2003 after extensive pilot plant trials that commenced on site in 1998 and this was the first of the NEWater plants. The larger part of its production water being sent to Wafer Fabrication plants, (high technology computer parts manufacturing), in the near vicinity.

Only a small percentage of the total NEWater product (around 2%) is currently being used for Indirect Potable Use (IPU).

It is understood that the total percentage of NEWater used for IPU from all of Singapore's plants will increase over the next 15 years to around 10% of Singapore's total demand and more if water demand increases.
Singapore officials advised that the uptake of new water by industry has exceeded their expectations. This uptake means that at present demand exceeds supply.

Bedok has current capacity of 32 ML/d, with an ultimate capacity of 82 ML/d. Across Singapore there are several other 'water factories' producing NEWater, current total production is around 248ML/d and is expected to increase to 530 ML/d by 2009. By comparison Canberra's stage 3 winter water consumption target is 97ML/d and the water2WATER proposal is likely to result in water production of 25ML/d initially with a later expansion of up to 50ML/d.

Singapore's water factories all incorporate dual membrane technology using Microfiltration (MF) or ultrafiltration (UF) membranes, Reverse Osmosis (RO) membranes and UV disinfection. Discussions with SUI management and technical experts indicated a very strongly held view that membrane filtration is 'cutting edge' technology that is no longer expensive to purchase or operate and offers the best approach to producing high quality and reliable water that consistently well exceeds WHO and other international drinking water standards.

When asked about their views on alternative technologies such as Biological Activated Carbon (BAC) they reiterated their views on the value of membrane filtration.

The key feature of the Bedok NEWater Factory is its Visitors Centre, which is central to the PUB NEWater public education program. The Visitors Center is built around the MF/RO/UV plant, allowing the public to view the operating plant from behind glass panels. An estimated 10,000 persons (including school children) visit the centre every month, with over 500,000 through the centre to date.

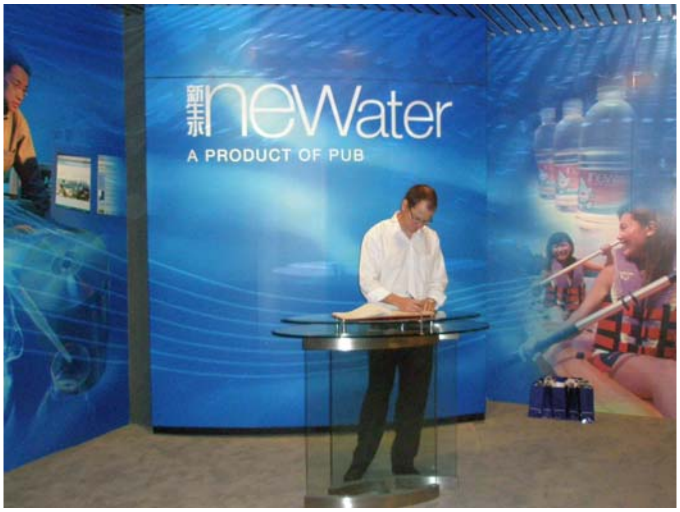
The PUB NEWater public education is extensive and commences with the engagement of children during their school years – a visit to the Centre for all children in Singapore is incorporated in the education curriculum to ensure children visit the plant at least once during their school life.

The Singapore Government has incorporated into it's overall water communications strategy two key themes – water conservation and an explanation of Singapore's approach to water supply; the 4 national taps policy.

The 4 National Taps are;

- Local catchments;
- Imported water;
- Desalination; and
- Indirect Potable Use (IPU): NEWater

Dr Dugdale, Chief Health Officer ACT Health signing the visitor book at the NEWater Visitor Center



SUI is a wholly owned subsidiary of PUB and supports PUB with cutting-edge water treatment technology. It is also the international commercialisation wing, effectively allowing PUB to bid on international water and wastewater projects and provide consulting and training services to other water utilities.

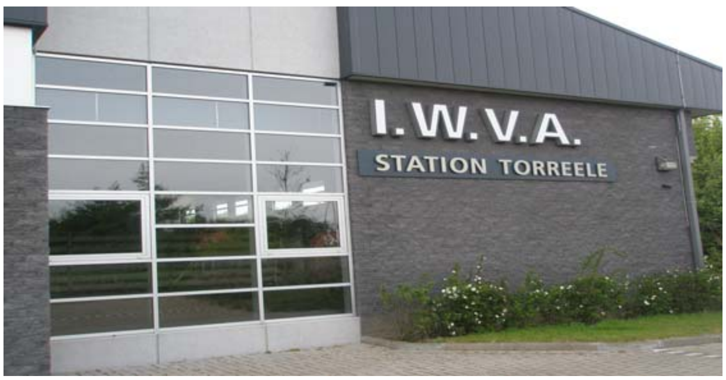
Given Singapore's extensive experience in both water treatment technology and the effective operation/implementation of IPU, ACT Health officials discussed the possibility of SUI undertaking water analysis of the effluent discharge from the Lower Molonglo Water Quality Centre to provide base line data on the sort of contaminants that will need to be considered in any subsequent risk assessment for the water2WATER project.

Environmental assessment was not a significant consideration in the NEWater scheme as the brine reject is blended with the remaining secondary treated effluent for discharge to the ocean outfall. Whilst not a great deal of work has been done on the environmental impacts the outfall to the ocean currently meets the standard imposed of 3000mg/L salt (Total Dissolved solids), which is less than 10% of the salinity of seawater which has a typical salt content of 35,000 mg/L salt.

3. Belgium:

• ***IWVA Water Treatment Plant, Wulpen.***

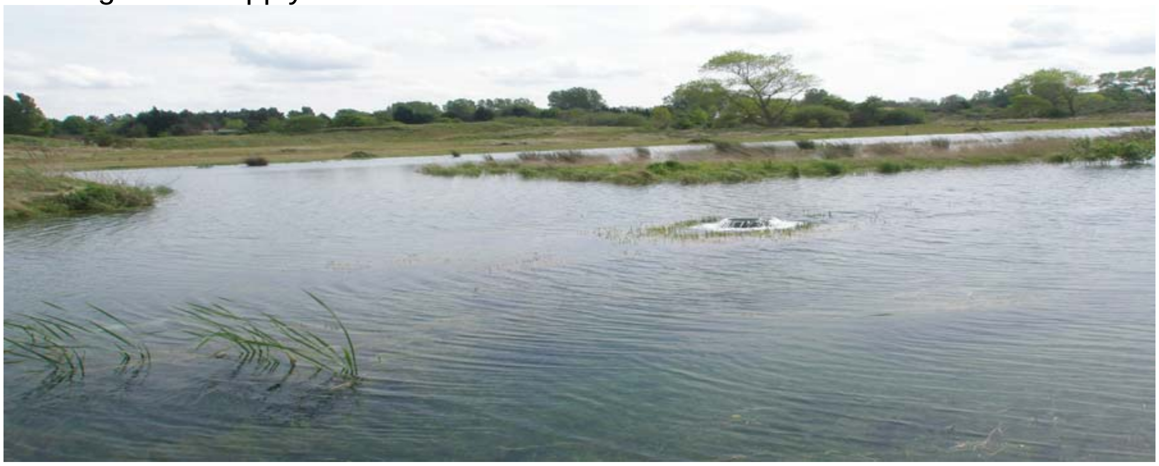
On the 16th May 2007 the group met with the Director-general of IWVA, Mr Johan Verbauwhede and Mr Emmanuel Van Houtte.



Torreele water reclamation plant, Wulpen, Belgium.

IWVA is a public water company that owns and operates water infrastructure supplying water to a population of around 60 000 in the west of Belgium.

IWVA operate its dual membrane Torreele water treatment plant at Wulpen as a part of its 'infiltration' water program. This program essentially uses highly treated wastewater effluent to recharge the ground water aquifer in the local dune water catchment. This aquifer is then used to provide a portion of the local drinking water supply.



Recharge lagoons, Walpen, Belgium

Recharge water from the reclamation unit is 'aggressive' and requires treatment to raise the pH and soften the water, however IWVA have indicated that this process is simple and results in no adverse health or environmental outcomes.

The Torreele plant commenced operation in July 2002 following infiltration tests in 1991 and 1993 and extensive pilot testing between 1996 and 2000.

The key driver for the company's decision to move to IPU relates to an over use of the groundwater supply. This supply, an aquifer under the coastal dunes was particularly 'stressed' in the summer months when tourism significantly increased water demand. There was significant concern that the aquifer could be impacted on by salt-water ingress. Consequently IWVA introduced IPU to recharge the aquifer and maintain a water balance to protect the ecology and sustainability of the groundwater.

A comprehensive assessment of environmental issues was undertaken prior to commissioning the plant and a continuing monitoring program, including terrestrial assessments, has demonstrated no adverse impacts except in extreme low flow conditions where salt loads are concentrated in discharge canals. The infiltration recharge environmental assessment and monitoring are incorporated into a more extensive dune protection and monitoring program that is enhanced with infiltration knowledge.

Amphibian life and some algal growth are colonizing the infiltration ponds.

IVWA are trialing aquatic plants to reduce nutrient levels in their discharge stream, but as yet have no reliable data on this trial.

Of particular interest is the decision taken by the company to cease the use of UV as a final disinfection process. This decision was taken on the basis that they believe that the membrane process, in conjunction with a 35-day detention in the dunes prior to extraction provided a sufficient barrier to microorganisms, organic and inorganic compounds.

4. United Kingdom, London and Essex:

- ***Thames Water, London.***

On the 17 May 2007 the group met with Ms Sian Hills, Sustainable Resources and Customer Research Manager, and Mr Graham Welland, Principle Advisor Water Quality Regulations for a discussion, under confidentiality, around experiences of effluent reuse.

Thames Water is a private water supply company that is responsible for provision of drinking water to a population of around 7 million and wastewater services to 12 million in the London area.

At present Thames Water do not have any ‘planned’ Indirect Portable Use (IPU) of recycled water occurring, although they recognize that as a consequence of upstream discharges of sewage into the Thames and other rivers in the area that there is considerable ‘unplanned’ IPU occurring.

Thames Water has been closely monitoring world trends with respect to the reclamation of water from sewer systems. They had proposed a desalination plant to supplement their water supplies, but there has been an initial planning ruling rejecting this proposal. This then went to Public Enquiry and a decision was announced on 15th June 2007 that the Government is ‘minded to’ grant planning permission for Thames Water Beckton desalination plant, subject only to an undertaking from Thames Water on the circumstances in which the plant will be used. In the intervening period Thames Water had produced a list of alternatives scenarios, should the desalination plant not eventually get approval, which included more mains upgrades, additional groundwater development, artificial recharge, increased monitoring activity and IPU, but many of these still required a longer term time horizon.

The delivery of IPU has been incorporated into the company’s forward water resources plans. This planning includes the introduction of IPU at an initial output of 25ML/d in 2017-2018. In the lead up to this date additional research, the introduction of a pilot plant and a comprehensive community engagement/education strategy will occur. The outcome of that process will inform the final decision.

Thames Water have already undertaken considerable investigations into the feasibility of IPU. Including consultation with operators of IPU schemes worldwide. They have concluded that the most probable technology to be adopted is micro/ultra filtration, reverse osmosis and advanced oxidisation.

This process train has been selected based on membrane technology's superior and reliable performance, particularly with respect to new and emerging small molecular weight chemicals and taking into account the urban nature of the London catchment area.

Thames Water advised that whilst membrane technology performs very well, there is evidence that small molecular weight compounds such as Nitrosodimethylamine (NDMA) may not be totally removed by membranes. In order to deal with such events the company intends to incorporate advanced oxidization as the final process step in future IPU schemes.

Aspects of the regulatory framework applicable to Thames Water were discussed. In essence the UK works to a variety of 'Directives' such as the 'Water Framework Directive', established by the European Union, the Drinking Water Directive which translates in England and Wales as The Water Supply (Water Quality) Regulations 2000 and finally the Urban Wastewater Directive.

Direct regulation of the water industry is undertaken by three Government Departments. The Environment Agency, which regulates discharges (such as treated effluent) to raw water sources and the Drinking Water Inspectorate, who regulate drinking water standards. Office of water services (Ofwat) are the financial regulator.

Thames Water have exceeded 99.98% compliance with drinking water standards in the last year for parameters measured at the customers tap.

The Water Treatment Plants (WTP) currently providing drinking water to London are advanced water treatment plants including slow sand filtration with carbon sandwich, ozonation and chloramination. The only changes required for IPU would be an expansion of capacity.

It is significant that Thames Water is operating on a 10 year time frame to fully implement planned IPU. Whilst the company acknowledged that there may be pressure to accelerate, they felt that there needed to be a significant lead time for investigation, community engagement and implementation. Clearly in the ACT there is considerably more urgency involved with the need to develop alternative water resources and a 10 year lead time is not feasible without a return to higher rainfall patterns in the very near future. The Thames Water approach to implementing IPU does however provide a useful comparison and perhaps highlights a degree of risk associated with the need to implement IPU quickly in the ACT.

- ***Environment Agency and Essex & Suffolk Water, Essex.***

On the 18 May the group met with Mr John Daniels, Regulatory Specialist, Water Quality, from the Environment Agency and Mr Adam Crysell, Process Control Technician from Essex & Suffolk Water. The meeting was held at Langford Water Treatment Works in Essex and included a tour of the treatment plant.

The Langford Recycling Scheme was developed in response to declining water resources in the region. This problem was amplified in 1997 when a significant drought resulted in an immediate need for additional water. In response to this need Essex and Sulfolk Water sought and obtained an emergency approval to use upstream fully treated sewage to supplement the local water reservoir at around 30ML/d. This approval was fairly short lived and the diversion of the treated sewage effluent into the reservoir ceased once it rained. This exercise did however generate significant public debate and led to the development of the Langford Recycling Scheme

Langford recycling plant, Essex England. From Left, Mr John Daniels Environment Agency; Mr Bob Neil ACT Government; Mr Adam Crysell Process Control Technician, Essex & Suffolk Water; Mr Hamish McNulty, ACT Government; Dr Paul Dugdale ACT Government.

The Langford Recycling plant receives sewage effluent from a sewage treatment plant upstream on the River Chelmer. This effluent, which would normally be discharged to an estuary, undergoes clarification, phosphate, nitrate and ammonia removal prior to UV disinfection at the Langford recycling plant. The treated water is then discharged into the River Chelmer about 4 kilometers upstream from the plant.

The River Chelmer water is then available for abstraction and treatment at the Langford Water Treatment Works for the production of drinking water. The recycling scheme only operates during the summer period when river levels decline.

The approach taken by Essex & Suffolk Water with respect to the Langford Recycling Scheme is quite different to operations reviewed by the group to date. The primary difference being that the Langford recycling plant is designed to treat the effluent to the extent necessary to make it suitable for discharge to a river. Following this treatment, and subsequent discharge upstream of the Water Treatment Works the combined river and reclaimed water is available for abstraction and after further treatment is used as drinking water.

The underling principle for the operation of the recycling and water treatment works is that it is the water treatment works (not the reclamation plant) that purifies the raw water (river plus recycled water) to drinking water standards.

This approach means that, with no specific process aimed at removing contaminants such as pharmaceuticals, pesticides etc at the recycling plant, such contaminants are left to the Langford Water Treatment Plant to treat. Pollution from these substances was not considered to be an issue for the river.

It is also worth noting that as Essex & Suffolk Water obtain treated sewage from an upstream Sewage Treatment Plant they have little control over this raw feed.

The Langford Water Treatment Works is a fairly conventional plant incorporating clarification and filtration, along with Activated Carbon filtration, ozonation and chlorination.

From a regulatory perspective the ‘Environment Agency’ is the primary regulator for the recycling scheme, as it discharges to a river. Regulatory responsibility for the Langford Water Treatment Works, which produces drinking water, rests with a separate regulatory authority, the Drinking Water Inspectorate.

The Environment Agency’s focus is very much centered around the ecology of the receiving waters, in this case the River Chelmer.

The Environment Agency has overseen extensive research and monitoring in the River Chelmer with a particular emphasis on estrogenic effects on fish. There has been no adverse environmental outcomes reported to date rather an improvement in environmental quality has resulted. Siltation at the river mouth (Blackwater Estuary) was a major community concern, due to the reduction in 'fresh water' flow, however there is no evidence of any impacts at this time.

With respect to contaminants such as Chlorine by-products including NDMA, the Environment agency indicated that they do not specifically monitor for such chemicals, as it is not likely to be a significant environmental contaminant in the river.

5. United States, Virginia, Washington DC and Sacramento:

- ***Virginia Department of Environmental Quality (DEQ), Woodbridge, Virginia.***

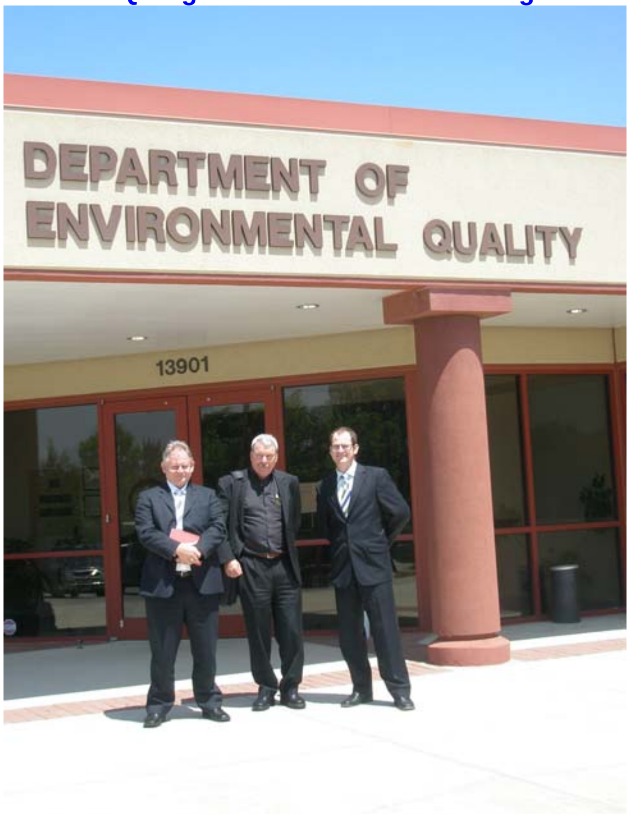
On the 21 May the group met with Mr Tom Faha, Water Permit Manager, and Ms Alison Thompson, Environmental Engineer at DEQ’s Northern Regional Office located in Woodbridge, Virginia.

From an effluent reclamation regulatory perspective the DEQ’s primary focus is on the protection of the receiving waters.

The DEQ's primary regulatory head of power comes from the national EPA's *Clean Water Act.* The DEQ then operates under delegation from the EPA with state based subordinate legislation and standards effectively mirroring that of the EPA.

The DEQ has seven regional Offices across the state. Within the Northern Region there are four water inspectors who among other duties conduct regular audits of discharge permits for sewerage treatment plants. Within the Northern Region DEQ office there are also a number of permit writers who focus on the statutory instruments that control activities such as water reclamation.

Mr Hamish McNulty, Mr Bob Neil and Dr Paul Dugdale at the DEQ Regional Office Woodford Virginia.



DEQ advise that whilst the state is quite 'rich' in water resources, receiving some 40 inches of regular rain per year, there is none-the-less still pressure in some areas on existing water resources. The biggest water reclamation project in the state is the Upper Occoquan Sewage Authority (UOSA) where past droughts have created considerable concern. The UOSA currently supplies water to a population of around 1,000,000 people.

In the 1970's, within the Upper Occoquan watershed a crisis of supply occurred during a severe drought. This drought resulted in poor water quality that included several severe algal blooms as well as taste and odour concerns. A major cause of the water degradation was the discharge of treated sewage of varying quality from several upstream treatment plants. During the drought this treated waste formed the major flow into the Occoquan Reservoir.

To address this problem, the UOSA was formed and a new sewerage treatment plant was commissioned. Other major sewerage treatment plants within the catchment were subsequently decommissioned and their sewerage piped to the new plant.

The Virginia State authorities and UOSA recognized the need for independent scientific advice as essential for public and regulatory confidence. As a result they established the Occoquan Watershed Monitoring Laboratory (OWML).

OWML monitors environmental and health issues, continues to accumulate knowledge and experience and provide expert advice. Current concerns include emerging modern chemical/pharmaceutical loads.

The new Upper Occoquan plant was able to produce a much higher (and more consistent) quality of water particularly in terms of nutrient loadings.

The result of the new plant was much better control of treated sewerage discharges, and a shift from ‘unplanned’ IPU to planned IPU with vastly improved raw water in the Occoquan Reservoir.

This facility has traditional secondary wastewater treatment followed by chemical precipitation, and physical treatment. The plant was originally designed for 12 Million Gallons (US) per day (MGD) and is currently operating at 54 MGD. The facility is considering a future expansion to 64 MGD.

More recently, a significant drought occurred some 5 years ago that has initiated more interest in water reclamation within the state of Virginia.

The Loudoun County Sanitation Authority’s Broad Run Water Reclamation Facility plant is currently being built and is due to be commissioned next year. This plant has incorporated a single membrane filtration following significant trials. These trials returned very good results and as a consequence membrane filtration was designed into the final process train.

As already discussed the State of Virginia deals with water reclamation resulting in indirect reuse, through environmental laws. This means that regulatory controls are aimed at the protection of the receiving waters, which then become raw water sources for water treatment plants that produce drinking water.

Health aspects of IPU are dealt with through the *Safe Drinking Water Act*, which is applied through the Health Department who regulate the Water treatment plants.

- ***Office of Water, United States EPA, Washington DC***

On the 22 May the group met with Mr Tom McCully, Senior Advisor International, Office of Water United States EPA; Mr Roger Gorke, Policy Advisor Office of Water United States EPA; Mr Robert Bastion, Senior Environmental Scientist, Office of Waster water Management, United States EPA; Ms Renee Morris, Environmental Protection Specialist, Office of Ground Water and Drinking Water, United States EPA; and Suzanne Kelly, Biologist, Office of Ground Water and Drinking Water, United States EPA.

Mr McCully gave a brief outline of the EPA’s primary functions as a regulator and policy maker within the domestic setting. Mr McCully also indicated that as a leading standards setter the EPA works closely with the United States Geological Survey Office to establish environmental benchmarks and baseline information that informs their environmental assessments.

The EPA also maintains strong links with the Office of Science and Technology who are currently studying discharges for new and emerging pollutants and with health regulators.

In the United States there are 18 Federal government agencies with a direct interest in water issues. One of the most complex of these issues is water rights, which has seen a split in approaches across the nation, with areas east of the Mississipi River being supplied on the basis of water defined as a 'common good' but west of the Mississippi River water is a tradable commodity promised and exchanged according to commercially enforceable and tradable contracts.

Within the United States water recycling projects are driven by factors such as climate change and drought as well as population growth. In this sense water quantity and water quality are closely linked. Water quantity is often the key driver of water quality issues. This can be seen in the Canberra debates on recycling brought on by the continuing drought.

It was noted that 'water politics' was generally more of an issue at a local level unless there were national infrastructure implications. Increasingly there has been a tendency to see water related issues caught up into the climate change debate, which is often not particularly helpful for the specific water issues.

It was noted that the Western Governers Association has a very good paper on water issues. http://www.westgov.org/wga/meetings/am2006/Water06.pdf

With respect to quality, the bar for recycling water was lower where there was a documented prexisting health threat, for example in the Occoquan Basin which prior to the construction of a large activated carbon based recycling plant was served by 12 small suboptimum sewerage treatment plants. However, if there was no existing threat, the bar for the quality of recycled water was higher than for water extracted from good quality conventional sources.

One of the negatives of recycling outlined by the EPA was the potential for a build up of unwanted contaminants as they cycle within the system - for example salt can build up if not removed during the process. On the issue of salt build up/disposal the EPA indicated that this can become a problem in inland areas where injection into inappropriate underground formations can lead to the mobilisation of arsenic if present.

The water-energy nexus is important to address in designing any significant water infrastructure if it is to be sustainable.

The EPA advised that recycling projects have the capacity to enhance land values. For example the Clayton County project in Georgia, involving a park based flow-through water polishing system, increased local land values. Wetlands created for water treatment can also push up surrounding suburban land values, due to their aesthetics.

Of interest was the EPA's advice that the Office of Science and Technology in the EPA was conducting a study on water quality involving the measurement of 500 specific parameters.

The EPA outlined the expansion of research and surveillance in relation to water quality within the United States and indicated their interest in strategic alliances/collaboration with Australia. The international water conference in the United States in October 2007 was mentioned as being the next major scientific meeting on recycling.

- ***Drinking Water Technical Programs Branch, California Department of Health Services, Sacramento, California.***

On the 23 May the group met with Mr Gary Yamamoto, PE., Chief Drinking Water Technical Programs Branch; Ms Cindy Forbes, PE., Chief Southern California Branch Drinking Water Field Operations; Mr Robert Hultquist, PE., Chief Northern California Drinking Water Field Operations Branch; Ms Heather Collins, PE., Chief, South Coast Section, Drinking Water Field Operations Branch.

This meeting provided an opportunity for the group to explore California's experiences in the area of drinking water recycling.

Whilst California has not yet had any drinking water recycling projects incorporating the use of surface water storage supplementation, their experiences in drinking water recycling associated with ground water recharge and reuse was very useful.

In particular the California Department of Health (CDH) were able to share some of their experiences in regulatory approaches to drinking water recycling as well as their experiences with two problems that occurred with ground water recharge schemes in southern California.

One particularly useful document provided by the California Department of Health was *the framework for regulating the Indirect Potable Reuse of Advanced Treated Reclaimed Water by Surface Water Augmentation in California.* This report originally prepared by the California Potable Reuse Committee in January 1996 is still considered by the Californian health officials, to be the most definitive document on surface water augmentation and is a contemporary and highly relevant report on the subject.

This report identified the following six recommendations to be met before drinking water recycling be allowed:

- Application of best available technology in advanced Wastewater Treatment with the Treatment Plant meeting operating criteria;
- Maintenance of appropriate retention times based on reservoir dynamics;
- Maintenance of Advanced Wastewater Treatment Plant Operating reliability to consistently meet primary microbiological, chemical and physical drinking water standards;

- Surface water augmentation projects using advanced treated reclaimed water must comply with applicable State of California criteria for groundwater recharge for direct injection with reclaimed water;
- Maintenance of Reservoir water quality; and
- Provision of an effective source control program;

These recommendations will be useful in designing a regulatory framework for the ACT to manage drinking water recycling.

Consistent with the approach to drinking water recycling demonstrated by the above recommendations CDH indicated a strong preference for a multiple barrier approach to drinking water recycling. CDH also highlighted the need for a natural barrier such as a surface reservoir, given the inability to do real time monitoring. Such a barrier would provide time to deal with system problems before distribution to the public.

Interestingly CDH indicated a view that a detention time in the order of some six months for drinking water recycling waters, prior to use as drinking water was considered desirable.

CDH outlined their view that membrane technology constituted the best available technology. This was in response to our raising the question of alternate technologies such as activated carbon. With respect to Activated Carbon technologies, CDH specifically raised concern at the likelihood of an increase in TDS in the receiving waters.

CDH also mentioned that drinking water recycling to surface water had been considered several years ago in San Diego but did not progress, for a variety of reasons including public lobbying. There is a body of work however around this project that may be of value and should be sourced as soon as possible.

With respect to managing the implementation of IPU CDH advocated the use of public meetings and independent expert panels.

6. Summary and conclusion:

This trip provided an excellent opportunity to review the various approaches to drinking water recycling within an international setting. The representatives from the various sites visited were happy to provide whatever information they could. The study group felt that there is a real commitment across many countries to share their learnings with others. In this sense there is scope for the ACT to learn much more from the international ‘players’ in drinking water recycling. Equally it is hoped that the ACT will also be able to share its experiences should drinking water recycling proceed.

There is no doubt that the networks developed through this trip will be invaluable as the dinking water recycling debate proceeds.

The ACT Chief Health Officer’s observations from this trip relating to recycling for Canberra are at attachment A

- ***Conclusion 1: Water reclamation and recycling is achievable in the ACT.***

  It is apparent from this study trip that there are many approaches to water reclamation and reuse. The differences within the various countries visited span both regulatory and technological issues.

  What is clear is that water reclamation and recycling is successfully and extensively carried out throughout the world.

- ***Conclusion 2: There is a body of international opinion/information that supports the ACTEW proposed reverse osmosis membrane based process train option over single or no membrane options;***
- ***Conclusion 3: That on the basis of available information ACTEW's reverse osmosis membrane based option would provide the best outcome for the ACT in terms of public health and a range of environmental values. This option does however present significant environmental challenges and these will need to be carefully considered;***

  There is a strong international view that reverse osmosis membrane technology is the most effective and reliable technology for drinking water recycling. Importantly membrane technology is able to provide consistently high quality treated water. This view was put to the group by PUB and SUI in Singapore, IWVA in Belgium, Thames Water in the UK, and the California Department of Health. The US EPA did not express a view as to which technology was preferred other than that which can be managed to minimize adverse environmental and human health impacts.

  The Virginia DEQ did not express a strong view on technology but did indicate that recent membrane trials had showed exceptionally good results.

  The UK Environment Agency did not express a particular view on technology and considered that more traditional technologies such as used in the Langford plant were adequate to minimize adverse environmental impacts whilst delivering a raw water source that was acceptable for further treatment after blending with the natural river flows.

  It is worth noting that of the agencies that were visited, those that did not strongly support membrane technology as a preferred option were largely concerned with protecting environmental values of receiving waters.

  The California Department of Health raised the issue of 'best available technology' as being a requirement for IPU to surface waters in California and indicated that their view was that at present Membrane Technology is the best available.

  - ***Action 1: Request ACTEW to provide performance data, including relevant research findings to compare drinking water recycling options. This data to focus in particular on the efficacy of the options***

to remove endocrine disruptors, small molecular weights compounds such as NDMA and other byproducts of disinfection, reliability and consistency, capacity for rapid in-process monitoring to detect system problems and future capacity to adapt to emerging chemical contaminants of concern.

- ***Action 2: Request ACTEW to provide advice about increased TDS and nutrient loadings in the Cotter reservoir for its proposed options.***

- ***Action 3: consider direct potable reuse in Health and Environmental Risk Assessments.***
  Some proponents of membrane technology (SUI and IWVA) were of the view that the technology was so effective that direct potable reuse was possible. Whilst this was a view expressed amongst some operators of membrane plants it is noted that these operators all used Indirect Potable Reuse.

- ***Conclusion 4.*** **Water resource availability is the major driver for the water2WATER recycling project and if there is a deterioration in resource availability further pressure will be experienced to fast track the proposal. There may be opportunities to address some of the expected environmental concerns in a staged approach relying on a mix of current and new methods of waste treatment.**
  Throughout the study tour several references were made to the need to manage source contaminants (such as pharmaceuticals and salt) for the sewerage influent. This is considered to be a critical activity for ACTEW to engage in.

  - ***Action 4: Request ACTEW to consider strategies to reduce influent loadings for contaminants such as salt, and pharmaceuticals.***

- ***Conclusion 5: ACT Health and TAMS should look for ways to participate in the research, regulation and development of drinking water recycling nationally and internationally; and***
  There is throughout the world a significant body of work occurring with respect to drinking water recycling. This offers great opportunities for the ACT to both learn from and contribute to this work as we look to solutions for maximizing water quality and quantity security.

  In addition the network of international contacts that have been developed from this trip will be useful in the future should the ACT decide to adopt drinking water recycling. On this basis these international relationships should be nurtured.

  Should the ACT adopt drinking water recycling, it will be critical that relevant ACT agencies put in place processes to ensure that staff develop and maintain a detailed understanding of issues surrounding the operation, potential environmental and health impacts of drinking water recycling including emerging trends in new waste stream management methods and influent control mechanisms.

- ***Action 5: ACT Health to collaborate with Singapore SUI to undertake base line analysis of outflows from LMWQC.***
- ***Action 6: ACT Health to source relevant documents associated with the proposed San Diego drinking water recycling project***

- ***Conclusion 6: A robust regulatory framework to control drinking water recycling is required in the ACT.***
  There were no definitive regulatory models that were identified from this trip that could readily be applied to the ACT. Indeed there were significant variations in the regulatory frameworks applied within the areas that were visited. Whilst all of the regulatory models seemed to provide an appropriate and safe drinking recycling outcome it was noted that in several countries the health and environmental regulatory environments were not necessarily well aligned.

  In the ACT, should drinking recycling proceed there is clearly a need to implement appropriate regulatory controls to manage both environmental and health risks. It is desirable to develop these regulatory controls so that as far is possible they are complimentary.

  This framework should include strategies to control pollutant sources upstreamof the LMWQCC.

  - ***Action 7: ACT Health and EPA to develop regulatory controls for drinking water recycling that are, as far as possible complimentary.***

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4 July 2007

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Attachment A

Recycling can improve Canberra's water security

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June 2007

What is water security?

Water security is fundamental to the sustainability of any city. Quantity, quality, distribution, collection, treatment and public confidence are entwined to establish the security of water as a public good. It requires well understood sources of water, sufficient storage to ride out expected variations in climate, high quality treatment plants, a sound distribution network, separate collection and treatment systems for used water and stormwater, flexibility in the system and its components, extensive quality control across the system, and public confidence in the quality of water supplied.

In river communities, recycling from one town to the next is the norm. Historically however, recycling within a town has been avoided as part of the separation of the distribution of drinking water and the collection of used water, and this approach has been seen as fundamental to securing the quality of the drinking water supply.

With the availability of new technology and advanced water systems engineering, things are changing. A number of cities around the world - including Singapore, Brisbane, London and San Diego - have recognised that controlled recycling can significantly improve water security. The question is, will this be the case for Canberra?

Does the Canberra region need to recycle?

In the grip of a prolonged drought, the ACT Government is now considering large scale, controlled recycling of waste water. This follows implementation of an impressive range of water security measures. These include subsidies for more efficient household water use, price increases, major upgrades of our two water treatment plants at Googong and Stromlo (where water from the Corin, Bendora and Cotter dams is treated), imposition of outdoor water use restrictions, supply of treated storm water and wastewater for irrigation of parks, bringing the Cotter dam back on line, linking the Googong and Cotter river dams to maximise our catchment potential, and extraction of water from the Murumbidgee.

All these measures have helped, but Canberra's water supply has continued to become less secure as the drought has continued. Seven years of below average rainfall has left Canberra with around 64 Gigalitres (GL= one billion litres) in the dams. This is a little less than one year's supply of water, not taking into account savings from stage 2 or 3 water restrictions. In 2006 inflow to the dams was 22GL. Hopefully, with the end of the El Nino Pacific weather pattern, more will be collected this year, but inflow for the first five months of 2007 has been below what it was last year.

Stage one water restrictions are now permanent. Stage two and three restrictions over the last couple of years have saved tens of GL. They have imposed an economic cost of several million dollars to Canberra and Queanbeyan over this period. There is a fleet of several dozen trucks carting non-potable water around the region all day every day. Householders, public and private land owners, the swimming pool, horticultural and building industries have all been affected. There has been widespread damage to playing fields, gardens and parks, and thousands of trees lost.

This century's rainfall pattern has occurred before, with the drought at the beginning of the twentieth century being as bad. However, rainfall in southeastern Australia is expected to decrease over the coming decades and our population will grow, as will our water use.

For the first time since the 1960s, in May we commenced drawing water from the Murrumbidgee at the Cotter pump station, and hope to take 10 GL this year in the months that it flows. It is treated at the Stromlo Water Treatment Plant and supplied to the city, its quality easily meeting the standards set out in the Australian Drinking Water Guidelines.

For much of the year the only significant, reliable source of water in the ACT is the treated outflow from the Lower Molongolo Water Quality Control Centre (LMWQCC). 25GL a year flows steadily into the Lower Molongolo, which then joins the Murumbidgee (several kilometres downstream from the Cotter pump station) and flows into NSW. The quality of the outflow is pretty good. It is at least as good as the Murrumbidgee water it joins; better when stormwater from Canberra is flowing. Time over the river course allows sunlight and the river ecosystem to digest any treatment byproducts, organic chemicals or microbes that the outflow may contain.

A water recycling system could capture18GL a year of the LMWQCC outflow and return it to a tributary of the Cotter river and thence back into Cotter dam and Canberra's water supply. On current consumption patterns, this reuse would lower our net annual water consumption by more than 25% to 47Gl a year.

Canberra's current total dam capacity is 207GL, or 3.2 years' supply based on our normal use of around 65 GL a year. If we recycle 18GL a year, our current reservoir capacity would be 4.4 years' supply. If recycling is combined with increasing the size of the Cotter dam from 4GL to 78GL as ACTEW has proposed, we will have a dam capacity of 281GL or 6.0 years' supply. Without recycling, 281GL would be 4.3 years' supply.

In summary, a recycling scheme will provide greatly improved water security for Canberra, significantly reduce the likelihood of water restrictions being needed in the future, and greatly reduce the chance of the existing dams running empty.

Combined with increasing the size of the Cotter dam, it will allow a major expansion of the population in the area.

How would recycling work?

Downstream reuse of waste water is common around the world in river communities. Waste water treatment plant outflows go into rivers. Towns downstream - like London on the Thames River, or Jugiong on the Murrumbidgee - take up the river water, treat it and supply it for drinking. The process will typically be repeated several times over the course of the river.

Less common is recycling of treated waste water back into water storage, as has been proposed for Canberra. Flanders in Belgium and Orange County in the USA take wastewater treatment plant outflows, treat the water again including pushing it through a polyamide membrane, then put the treated water into the ground and take it out again through bores. Singapore pipes similarly treated water into their main reservoir. Queensland has commenced construction of a similar membrane treatment/pipe to reservoir scheme.

The standard of treatment for recycling should be higher than the standard for downstream reuse of potable water because the cycling of the water can allow the build up of contaminants generated within the cycle, creating the possibility that the concentration of a chemical or virus in the water may build up over months or years as the water cycles around.

This type of planned water recycling needs to be carefully designed and operated, through the whole cycle from drain to tap. Public flushing of drugs and down the toilet should be discouraged. Industrial, hospital and laboratory waste discharge into the sewers needs to be closely controlled. Operation of the waste water treatment plant must be optimised and kept under close surveillance, with careful monitoring of the outflow water. Careful consideration needs to be given to the potential for treatment to actually create contaminants – for example chlorination acting on chemicals in the wastewater can create Trihalomethanes (THM) and N-nitrosodimethylamine (NDMA), which can cause cancer in humans. If these are created, they need to be removed.

The conventionally treated water should then go through the best treatment process available to remove parasites, bacteria, viruses, organic molecules including pesticides, pharmaceuticals and hormones, and inorganic molecules including heavy metals and disinfection by-products.

Internationally, there is a consensus that the best available water treatment processes include reverse osmosis through a polyamide membrane. Imagine a semipermeable membrane with pure water on one side and salty water on the other. Osmosis is the process whereby some of the pure water flows through the membrane to dilute the salty water. When pressure is applied to the salty water, the water flows in the reverse direction, increasing the volume of pure water and leaving more concentrated salty water behind. This process is called reverse osmosis.

The outflow from a conventional sewerage treatment plant such as LMWQCC includes a significant load of very fine solids. If unfiltered this water will block the reverse osmosis membranes, so it needs to be put through a microfiltration membrane prior to going through the reverse osmosis membrane. If the water is to be recycled with only a short transit time in the environment as is proposed for Canberra, it should then be put through an oxygenation step including irradiation with Ultra Violet light to degrade small molecules that can pass through the reverse osmosis membrane.

It is then beneficial for the clean water to flow through a wetland and creek before reaching the storage. This allows some time in the environment (which becomes time to implement a response in the event a problem with the system is detected) and further adsorption or degradation of small organic molecules by soil organisms and plant root systems. Flow down a creek allows volatile molecules to escape into the air. Ideally, the storage should be large enough to provide an additional barrier that takes the treated water a few days to traverse before being drawn upon again. It should then go through a further conventional treatment plant before being supplied to the town.

The control of the recycling processes needs to be detailed and robust. It should include licensing conditions imposed by environmental and health regulators. It must aim for compliance with the National Drinking Water Guidelines. Treatment plants should be accredited. There needs to be an extensive sampling regime at critical control points in every step of the system, and regular testing for a wide range of microbes, unwanted molecules and physical properties such as water pressure and conductivity.

Plans must be in place for what to do when problems are detected. Staff must be trained and kept up to date, and teamwork encouraged between people with all the different roles involved. Regular reports must be provided to the regulators, government and the public. Problems should be disclosed and dealt with openly as they arise.

Recycling and sustainability

Recycling plants and dams are expensive. They are major pieces of infrastructure for the sustainable development of Canberra and their cost is comparable to a multistorey office block or a new dual carriageway road. International experience shows that water recycling is often the most cost effective way to bring on a new source of water in areas where water is scarce, compared to new dams, pipeline projects or desalination plants.

Citywide recycling will be much cheaper than widespread adoption of residential greywater recycling and installation of rainwater tanks to reduce demand for town water. Of course, the two approaches can go hand in hand, and motivated householders who take care to follow rainwater and greywater reuse guidelines are making an important contribution to reducing our demand for water.

However, a 25% reduction in demand through onsite residential measures would be extremely difficult to achieve. Large sticks and large carrots would be required. Making a myriad of unmotivated householders responsible for the maintenance and use of the systems could create multiple small health hazards that cannot be effectively regulated. Systems of self reliance require much more land and space between neighbours than the quarter acre block provides. Urban living requires a collective approach to natural resource use and waste disposal, and water is no exception.

The impact of the recycling on the environment should be positive or neutral rather than negative. By-products of the treatment process, such as sludge, salt and wastewater, should be disposed of without negative environmental impact. The whole process should not result in net carbon dioxide release into the atmosphere. Clean energy should be sourced for the process or carbon sinks established as part of the set up.

A number of factors are at play that will increase the pressure for Canberra to adopt water recycling. Our expected growth, arid inland location and declining rainfall are the sticks. Improving technology, growing international experience and reducing membrane costs are the carrots.

If Canberra is going to develop water recycling, the current level of our water storage makes a strong argument for commencing to build it sooner rather than later. However, recycling is complex. The design, research and development of the process should not be rushed. The different components need to be tested thoroughly and commissioned in the proper sequence. The water should not be drawn upon until everything is working smoothly, all monitoring systems are in place and the quality of the water has been proven. Until then, the water should be allowed to flow down the Murumbidgee.

If it rains and our dams are filled, the recycled water will just overflow the Cotter dam and head downstream to NSW. But if the dams don't fill, or we have another drought in the future, it would be there to use.